Gas Laws, the Mole and Gas Properties

Particles in Solids

- are closely packed and tightly bound to each other resulting in a fixed volume and shape

- constantly vibrate but this is the only movement they are capable of as they are tightly bound

- vibrate, on heating, more and more, until, at the melting point, they break free from each other and a liquid is formed

Particles in Liquids

- are still close together but can slip by one another easily resulting in the ability to flow and not having a fixed shape

Particles in Gases

- are relatively free of each other and move around rapidly and randomly causing the gas to fill the container and hence a gas has no fixed shape or volume (and can be compressed)

- move in random, rapid motion, colliding with each other and the walls of the container

Diffusion

Diffusion is the spontaneous spreading out of a substance due to the natural movement of its particles

Demo: diffusion of ammonia and hydrogen chloride gases

Chemicals: concentrated hydrochloric acid
concentrated ammonia solution

Place a piece of glass wool soaked in conc. hydrochloric acid at one end of a horizontal glass tube.

Place a piece of glass wool soaked in conc. ammonia solution at the other end of the tube.

Result: a white cloud of ammonium chloride is formed where the gases come in contact

Boyle's Law

For a fixed mass of gas at a fixed temperature, the pressure of the gas is inversely proportional to the volume of the gas.

$P \propto \frac{1}{V}$ $P = k . \frac{1}{V}$ $PV = k$ $P_1V_1 = P_2V_2$ gases only

Charles' Law

At constant pressure, the volume of a fixed mass of gas is directly proportional to its temperature on the Kelvin scale.

$V \propto T$ $\frac{V}{T} = k$ $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ gases only

Gay-Lussac's Law of Combining Volumes

In a gaseous reaction, the volumes of gaseous reactants and any gaseous products are in the ratio of small whole numbers provided volumes are measured at the same conditions of temperature and pressure.

Avogadro's Law

Equal volumes of gases contain equal numbers of molecules under the same conditions of temperature and pressure.

Avogadro's Constant (L)

Is the number $6x10^{23}$, which is the number of particles contained in one mole of any substance.

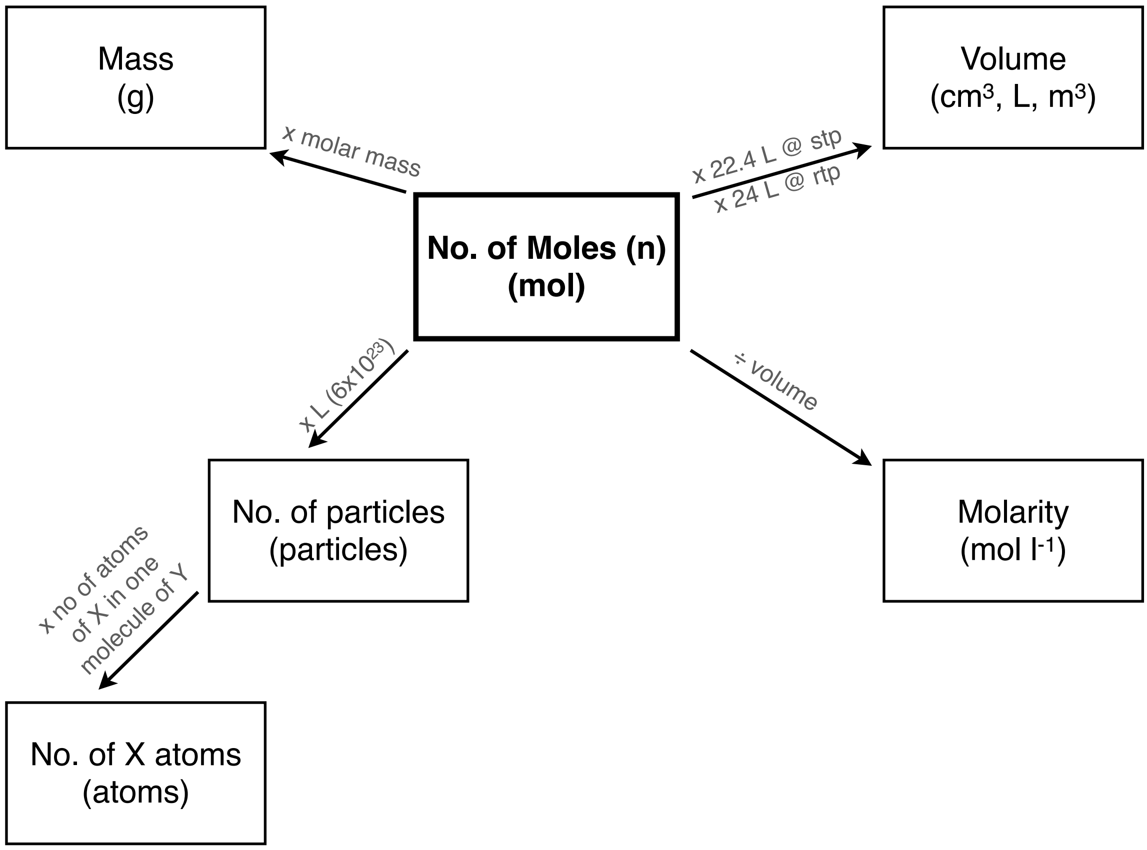
Combined Gas Law

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

gases only

Mole Conversions

The chemical equation gives the molar relationship/ratio.
The chemical formula gives the atomic ratios.



Constants, Standards and Conversions

°C → K: +273

Standard Temperature: 273 K
Standard Pressure: 101, 325 Pa
760 mm Hg

$L = 6 \times 10^{23}$

Molar Volume at s.t.p.: 22.4 l
$22400\ cm^3$
$2.24 \times 10^{-2}\ m^3$

$cm^3 \rightarrow m^3$: $\times 10^{-6}$

Kinetic Theory of Gases

Assumptions:

- a gas is made up of particles whose diameters are negiligible compared to the distances between them

- there are no attractive or replusive forces between these particles

- the particles are in constant rapid random motion, colliding with each other and with the walls of the container

- the average kinetic energy of the particles is proportional to its temperature on the kelvin scale

- all collisions are perfectly elastic

Limitations:

- only completely valid for ideal gases

Ideal Gases

An ideal gas is one which perfectly obeys all gas laws under all conditions of temperature and pressure.

Real gases deviate to the greatest extent from ideal behavior at low temperatures and high pressures as:

- the diameters of the particles are not negligible compared to the distances between them (assumption not valid)

- attractive and repulsive forces between molecules such as van der Waals' forces, dipole-dipole forces or hydrogen bonding have noticeable effects as the particles are in close proximity to each other

Equation of State for an Ideal Gas

- called so as it is only followed approximately by real gases

$$PV = nRT$$

P: Pa; V: m^3; n: mol; R: $J\ K^{-1}\ mol^{-1}$; T: K

gases only

Volumetric Analysis Equations Summary

$$\text{moles} = \frac{\text{mass (g)}}{M_r\ (\text{g mol}^{-1})}$$ solids / liquids / gases

$$\text{molarity} = \frac{\text{mass per litre}}{M_r\ (\text{g mol}^{-1})}$$ liquids only

$$\text{moles} = \frac{\text{volume (cm3) x concentration (M)}}{1000}$$ solutions (mol l^{-1}) only

$$\%\ w/v = g/100cm^3$$

$$\%\ w/w = g/100g$$

$$\%\ v/v = cm3/100cm3$$

$$V_{dilute} \times M_{dilute} = V_{conc} \times M_{conc}$$ dilutions of solutions (mol l^{-1}) only

$$\frac{M_1V_1}{n_1} = \frac{M_2V_2}{n_2}$$ reactions between an acidic solution and a basic solution

Gas Laws Equations Summary

$$P_1V_1 = P_2V_2 \quad \text{[constant T]}$$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \quad \text{[constant P]}$$

Avogadro's law of equal volumes

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$PV = nRT$$